

FERROALLOYS

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Ferroalloys are alloys of iron that contain one or more other chemical elements. These alloys are used to add these other elements into molten metal, usually in steelmaking. The top six ferroalloy producers in the world in 2002, in decreasing order, were China, South Africa, Ukraine, Kazakhstan, Russia, and Norway. Ferroalloys impart distinctive qualities to steel or cast iron or serve important functions during the production cycle.

The ferroalloy industry is closely associated with the iron and steel industry, its largest consumer. World production in 2002 of bulk ferroalloys was estimated at 16.7 million metric tons (Mt), a 3.9% increase compared with a revised figure of 16.1 Mt in 2001. U.S. bulk ferroalloy reported consumption in 2002 was 1.1 Mt. Increases in consumption occurred in the ferrochromium, 15%, and ferrosilicon, 10%. Bulk ferroalloys manganese (including silicomanganese) consumption was 4% lower than that of 2001. Total U.S. ferroalloy production, calculated on a gross weight basis, decreased by 10%. Total U.S. ferroalloy imports, gross weight, rose by 11% and exports dropped by 18%. These percentages reflect the sharp downturn in the U.S. economy in which the steel industry was significantly affected.

The principal ferroalloys are those of chromium, manganese, and silicon. Manganese is essential to the production of virtually all steels and is important to the production of cast iron. Manganese is used to neutralize the harmful effect of sulfur and as an alloying element. Silicon is used primarily for deoxidation in steel and as an alloying element in cast iron. Boron, chromium, cobalt, columbium (niobium), copper, molybdenum, nickel, phosphorus, titanium, tungsten, vanadium, zirconium, and the rare-earth elements are among the other elements contributing to the character of the various alloy steels and cast irons (Brown and Murphy, 1985, p. 265).

Compared with that of major ferroalloy-producing countries, U.S. ferroalloy production was moderate in silicon and manganese and relatively low in other ferroalloy metals. Consequently, U.S. ferroalloy production met only a small percentage of domestic demand. One important exception is ferrosilicon. For all forms of silicon, the United States has been meeting about 70% of its needs.

In countries with competitive mineral resources, the trend is toward production of value-added products, particularly in the case of chromium. Because of the unlikely prospect of new or expanded U.S. production and because of the uncompetitive U.S. mineral resources for most of the ferroalloy metals, the overall domestic ferroalloy production trend is one of decline. By 1999, U.S. production of ferronickel and common grades of ferrochromium had ceased. In both cases, when production stopped, resources were low grade, producers were relying on imported ore for feedstock, and operating costs were high. In contrast, ferrosilicon and manganese ferroalloy production have fluctuated, with ferrosilicon production decreasing and manganese ferroalloy production increasing steadily during the past 6 years.

Alternative materials, principally alloy scrap and oxide, have gained moderately on ferroalloys per ton of steel production during the past 20 years. A decrease in unit consumption is significant during the long term for the ferroalloy industry because such a decrease moderates any increase in ferroalloy consumption resulting from greater steel production. A combination of factors, including technology, availability, and price, is responsible for this general decline in unit consumption of the ferroalloys.

U.S. customer needs for ferroalloys in alloy and stainless steel for a multitude of applications have been and will continue to be strong, even while the steel industry continues to improve processing technology to reduce raw materials needs, and metallurgists develop steel grades with lower alloying metal content and equal or better performance to lower materials costs. For many stainless steel applications, there are not acceptable substitutes, and their key constituents, chromium and nickel, are essential. As technology and industry practices result in greater efficiency of use of ferroalloys, the strong demand for metals in construction, the chemical industry, transportation, and household appliances is expected to more than offset any basic reduction in unit consumption in the future. Competition from other materials, such as plastics and nonferrous metals in the transportation sector, will be strong, but the use of lightweight, high-strength grades is expected to make steel competitive for many years (Sibley and others, 2001, p. 40).

Chromium, manganese, silicon, and other metals contained in ferroalloys are discussed in more detail, including domestic data coverage and outlook and U.S. Government stockpile, in the respective mineral commodity chapters in the U.S. Geological Survey Minerals Yearbook. These chapters are also published individually in the Mineral Industry Surveys Annual Review series. The tables in this chapter contain information on all ferroalloys for which data are available.

The major world chromite ore-producing countries in 2002 were India, Kazakhstan, and South Africa. Brazil, Finland, Turkey, and Zimbabwe were significant chromite ore-producing countries. Most chromite ore was smelted in electric arc furnaces to produce ferrochromium for use by the metallurgical industry. Stainless steel manufacture consumed most ferrochromium. South Africa was the largest ferrochromium-producing country. China, Finland, India, Kazakhstan, Russia, and Zimbabwe produced significant amounts of ferrochromium. Europe (primarily Western Europe and Scandinavia including Belgium, Finland, France, Germany, Italy, Spain, Sweden, and the United Kingdom), Asia (Japan, Korea, and Taiwan), and the United States were the major stainless steel producing areas of the world. These areas accounted for 80% of world stainless steel production.

The ferrochromium industry developed in close proximity to the stainless steel industry. However, the closing of ferrochromium

facilities in these producing areas has resulted in the migration of ferrochromium production to chromite-producing areas. The world chromium industry in 2002 operated with production capacity in excess of demand. In anticipation of demand growth, new ferrochromium-producing plants were brought into production, under construction, and planned in South Africa. Four industry trends were evolving—(1) ferrochromium production using environmentally friendly, energy- and recovery-efficient, pre-reduction, closed-furnace process; (2) chromium recovery from ferrochromium slag; (3) consolidation of ownership in both the ferrochromium and stainless steel production industries; and (4) strategic alliances between the latter two industries.

Manganese ferroalloys, consisting of various grades of ferromanganese and silicomanganese, are used to provide a key ingredient for steelmaking (Matricardi and Downing, 1995, p. 970). Most U.S. supply was imported. The leading foreign source of ferromanganese and silicomanganese was South Africa, whose exports of manganese ferroalloys to the United States were greater than those of the next five largest importing countries combined (Australia, Brazil, France, India, and Mexico). Manganese ferroalloys were produced domestically, mainly at a plant near Marietta, OH, owned by France's Eramet, with some production at the recently converted manganese ferroalloy plant located at New Haven, WV, owned by the Israeli company Highlanders Alloys, LLC. Eramet Group and BHP Billiton PLC of the United Kingdom accounted for a significant portion of the world's production of manganese ferroalloys.

In addition to its U.S. plant, Eramet controlled plants in China, France, Italy, and Norway, and BHP Billiton controlled plants in Australia and South Africa. On a country basis, China continued to be by far the largest producer of manganese ferroalloys, with an output greater than that of South Africa and Ukraine combined, the countries with the next largest production.

Demand for silicon ferroalloys is driven principally by the production of steel and cast iron (Dosaj, 1997, p. 1115). On the basis of content, U.S. production of silicon ferroalloys decreased to 48% in 2002 from 57% in 2001, because of a significant increase in ferrosilicon and silicon metal imports in 2002. Silicon metal imports were at an alltime high in 2002. China was estimated to be the world's largest producer of ferrosilicon, with production 1.3 times greater than that of the next two largest producing countries combined—Norway and Russia. This chapter includes data for silicon metal, which generally was produced like ferrosilicon in submerged arc furnaces. While some silicon metal was used as a ferroalloy in 2002, the bulk of it was used as an alloying agent with aluminum and in the production of chemicals, especially silicones.

References Cited

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TABLE 1
GOVERNMENT INVENTORY OF FERROALLOYS, DECEMBER 31, 2002¹

(Metric tons of alloy unless otherwise specified)

Alloy	Inventory
Ferrochromium:	
High-carbon	531,000
Low-carbon	232,000
Ferromanganese, high carbon	731,000
Ferrotungsten, contained tungsten kilograms	404,000

¹Data are rounded to no more than three significant digits.

Source: Defense National Stockpile Center.

TABLE 2
REPORTED U.S. CONSUMPTION OF FERROALLOYS AS ALLOYING ELEMENTS BY END USE IN 2002^{1,2}

(Metric tons of alloys)

End use	FeB	Manganese		FeP	FeSi	FeTi
		FeMn	SiMn			
Steel:						
Carbon and high-strength low-alloy	675	212,000 ³	53,300	3,830	11,500 ^{3,4}	3,100
Stainless and heat-resisting	192	13,200 ³	2,920	--	44,400 ³	2,760
Other alloy	(5)	19,600 ³	8,680	745	6,900 ³	75
Tool	--	(3)	17,900	--	25,700 ³	(6)
Unspecified	--	1,120	211	(6)	37,100 ⁷	--
Total steel	867	246,000	83,000	4,580	126,000	5,930
Cast irons	--	7,430	1,190	1,480	144,000	11
Superalloys	99	(8)	--	(7)	110 ^{7,9}	1,410
Alloys (excluding alloy steels and superalloys)	281	18,400	(4)	(7)	177,000 ^{4,9}	643
Miscellaneous and unspecified	--	(8)	(4)	16	53,600 ⁸	(7)
Grand total	1,250	272,000	84,200	6,070	500,000	8,000
Total 2001	1,300 ^r	285,000	86,500	6,340 ^r	456,000	8,200 ^r
Percentage of 2001	96	95	97	96	110	98
Consumer stocks, December 31	1,190	21,200 ¹⁰	13,600 ¹⁰	1,040	18,600	3,730

^rRevised. -- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²FeB, ferroboron, including other boron materials; FeMn, ferromanganese, including manganese metal and other manganese alloys; SiMn, silicomanganese; FeP, ferrophosphorus, including other phosphorus materials; FeSi, ferrosilicon, including silicon metal, silvery pig iron, silicon carbide, and inoculant alloys; FeTi, ferrotitanium, including titanium scrap and other titanium materials.

³All or part included with "Steel, unspecified."

⁴All or part withheld to avoid disclosing company proprietary data.

⁵Included with "Steel, stainless and heat-resisting."

⁶Included with "Steel, other alloy."

⁷All or part included with "Cast irons."

⁸Included with "Alloys (excluding alloy steels and superalloys)."

⁹Part included with "Miscellaneous and unspecified."

¹⁰Includes producer stocks.

TABLE 3
REPORTED U.S. CONSUMPTION OF FERROALLOYS AS ALLOYING ELEMENTS BY END USE IN 2002^{1,2}

(Metric tons of contained elements unless otherwise specified)

End use	FeCr	FeMo	FeNb	FeNi	FeV	FeW
Steel:						
Carbon and high-strength low-alloy	5,530 ³	480	705	--	1,630	(4)
Stainless and heat-resisting	181,000	496	529	12,500	38	(4)
Other alloy	14,100 ⁵	1,940	1,090	60	748	(4)
Tool	3,010	W	(3)	--	270	(4)
Unspecified	W	--	--	--	--	(4)
Total steel	204,000	2,920	2,330	12,500	2,690	285
Cast irons	W	361	--	(6)	W	--
Superalloys	6,720	55	813	--	12	(4)
Alloys (excluding alloy steels and superalloys)	1,540	92	W	5	W	(4)
Miscellaneous and unspecified	12,900 ⁷	110	9	--	382	--
Grand total	225,000	3,540	3,150	12,500	3,080	285
Total 2001	195,000 ^r	3,080 ^r	4,230	10,500	3,210	343
Percentage of 2001	115	115	74	120	96	83
Consumer stocks, December 31	8,340	428	NA	114	197	20

^rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified." -- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²FeCr, ferrochromium, including other chromium ferroalloys and chromium metal; FeMo, ferromolybdenum, including calcium molybdate; FeNb, ferrocolumbium, including nickel columbium; FeNi, ferronickel; FeV, ferrovanadium, including other vanadium-carbon-iron ferroalloys; and FeW, ferrotungsten.

³All or part included with "Steel, other alloy."

⁴Included with "Total steel."

⁵Includes full alloy and high-strength low-alloy steel.

⁶Included with "Alloys (excluding alloy steels and superalloys)."

⁷Includes cast irons, electric steel, and unspecified uses.

TABLE 4
FERROALLOY PRICES IN 2002

	High	Low	Average ¹
Chromium:			
Ferrochromium:			
0.05% carbon ²	85.00	61.00	73.00
0.10% carbon ²	77.00	54.00	65.00
0.15% carbon ²	67.00	50.00	60.00
Over 4% carbon:			
50-55% chromium ²	36.00	28.25	31.68
60-65% chromium ²	36.00	27.00	31.88
Columbium, ferrocolumbium ³	7.00	6.50	6.68
Manganese:			
Medium-carbon ferromanganese ²	52.00	32.00	40.05
Standard-grade ferromanganese ⁴	590.00	440.00	493.46
Silicomanganese ⁵	28.00	20.00	24.37
Molybdenum:			
Ferromolybdenum ⁶	8.50	3.00	4.89
Molybdenum oxide ⁶	8.30	2.40	3.75
Silicon:			
50% ferrosilicon ²	50.00	34.00	41.05
75% ferrosilicon ²	40.00	29.00	32.84
Silicon metal ⁵	61.00	48.50	53.21
Vanadium, ferrovanadium ⁶	4.25	4.05	4.15

¹Annual time-weighted average.

²Cents per pound of contained element.

³Dollars per pound of contained element, standard (steelmaking) grade.

⁴Dollars per long ton.

⁵Cents per pound.

⁶Dollars per pound of contained element.

Sources: American Metal Market, Platts Metals Week, and Ryan's Notes.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION AND EXPORTS OF FERROALLOYS AND FERROALLOY METALS IN 2002¹

(Metric tons unless otherwise specified)

Alloy	Imports			Exports		
	Gross weight	Contained weight	Value (thousands)	Gross weight	Contained weight	Value (thousands)
Ferroalloys:						
Chromium ferroalloys:						
Ferrochromium containing:						
More than 4% carbon	283,000	169,000	\$92,300	13,500	8,710	\$7,140
Not more than 4% carbon	XX	XX	XX	2,070	1,250	2,640
More than 3% but not more than 4% carbon	--	--	--	XX	XX	XX
More than 0.5% but not more than 3% carbon	8,040	4,960	4,710	XX	XX	XX
Not more than 0.5% carbon	25,600	17,000	26,200	XX	XX	XX
Ferrochromium-silicon	28,900	12,000	11,800	281	97	290
Total	345,000	203,000	135,000	15,900	10,100	10,100
Manganese ferroalloys:						
Ferromanganese containing:						
More than 4% carbon	212,000	168,000	83,800	XX	XX	XX
More than 2% but not more than 4% carbon	5,890	3,030	2,320	XX	XX	XX
More than 1% but not more than 2% carbon	46,000	37,000	26,600	XX	XX	XX
Not more than 1% carbon	11,500	9,510	11,300	XX	XX	XX
Ferromanganese, all grades	XX	XX	XX	9,230	XX	6,300
Silicomanganese	247,000	165,000	111,000	523	XX	439
Total	522,000	383,000	235,000	9,750	XX	6,740
Silicon ferroalloys:						
Ferrosilicon containing:						
More than 90% silicon	44	27 ²	220	5,530	3,340	3,990
More than 55% but not more than 80% silicon and more than 3% calcium	1,990	1,290	1,680	XX	XX	XX
More than 55% but not more than 80% silicon and not more than 3% calcium	165,000	123,000	90,600	XX	XX	XX
Magnesium ferrosilicon	25,300	10,900	18,800	XX	XX	XX
Ferrosilicon, other ³	14,500	4,730	8,830	7,150	3,280	6,660
Total	207,000	140,000	120,000	12,700	6,620	10,600
Other ferroalloys:						
Ferrocerium and other pyrophoric alloys and other	101	NA	1,220	XX	XX	XX
Ferrocolumbium	6,200	NA	52,500	126	NA	1,500
Ferromolybdenum	5,570	3,590	30,900	19,500	NA	112,000
Ferronickel	34,200	12,300	81,200	69	46	879
Ferrophosphorus	9,470	NA	1,670	1,250	NA	860
Ferrotitanium and ferrosilicon-titanium	3,700	NA	\$9,960	834	NA	\$2,340
Ferrotungsten and ferrosilicon-tungsten	632	480	2,930	14	7	26
Ferrovanadium	3,160	2,520	19,400	189	142	1,550
Ferrozirconium	167	NA	295	868	NA	1,370
Ferroalloys, other	20,700	NA	24,500	7,650	NA	7,430
Total	83,900	XX	225,000	30,500	XX	128,000
Total ferroalloys	1,160,000	XX	715,000	68,800	XX	155,000
Metals:						
Chromium (total, all grades)	7,430	XX	42,800	745	XX	7,450
Manganese, other:						
Unwrought	19,400	XX	26,800	1,820	XX	6,900
Other	1,130	XX	2,260	XX	XX	XX
Silicon:						
Less than 99% silicon	41,000	39,900	35,500	7,940	7,710	14,100
Less than 99.99% but not less 99% silicon	104,000	104,000	125,000	1,380	1,370	2,540
Not less than 99.99% silicon	1,410	XX	75,900	5,920	XX	289,000
Total	174,000	XX	308,000	17,800	XX	320,000
Grand total	1,330,000	XX	1,020,000	86,600	XX	475,000

NA Not available. XX Not applicable. -- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Data adjusted by the U.S. Geological Survey.

³Includes less than 55% silicon and greater than 80% silicon.

Source: U.S. Census Bureau.

TABLE 6
FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE^{1, 2}

(Metric tons, gross weight)

Country, furnace type, and alloy type ^{3, 4, 5}	1998	1999	2000	2001	2002 ^e
Albania, electric furnace ferrochromium	30,252	28,120	12,500 ^r	11,900 ^r	22,800
Argentina, electric furnace:					
Ferromanganese	5,016	--	--	--	--
Ferrosilicon	11,245	2,568	2,500 ^e	2,740 ^r	2,500
Silicomanganese	25,388	--	4,900	5,150 ^r	5,000
Silicon metal	7,000	8,000	8,000 ^e	8,000 ^e	8,000
Other ⁶	22,974	13,850	16,900 ^r	9,925 ^r	10,000
Total	71,623	24,418	32,300 ^r	25,815 ^r	25,500
Australia, electric furnace: ^e					
Ferromanganese	110,000	98,000	115,000	115,000	115,000
Silicomanganese	105,000	116,000	135,000	135,000	135,000
Silicon metal	30,000	30,000	30,000	30,000	30,000
Total	245,000	244,000	280,000	280,000	280,000
Austria, electric furnace: ^e					
Ferronickel	4,500	4,250	4,200	4,000	4,000
Other	5,000	5,000	5,000	4,000	4,000
Total	9,500	9,250	9,200	8,000	8,000
Belgium, electric furnace, ferromanganese ^{e, 7}	20,000	--	--	--	--
Bhutan, electric furnace, ferrosilicon ^e	18,000	18,000	15,000	16,000	16,500
Bosnia and Herzegovina, electric furnace: ^e					
Ferrosilicon	1,000	1,000	1,000	1,000	1,000
Silicon metal	200	200	200	200	200
Total	1,200	1,200	1,200	1,200	1,200
Brazil, electric furnace:					
Ferrochromium ⁸	72,507	90,784	142,522	110,462 ^r	169,658 ⁹
Ferrochromiumsilicon ^e	5,000	5,000	5,000	5,000	5,000
Ferromanganese	122,000	116,822 ^r	121,277	96,016	96,000
Ferronickel	26,389	19,807	19,315	17,966 ^r	20,000
Ferrosilicon	166,278	200,833	188,735	159,345	160,000
Silicomanganese	124,000	116,822 ^r	171,304	180,235	180,000
Silicon metal	124,000	120,000	166,344	112,123	115,000
Other ^e	76,000	76,000	76,000	76,000	76,000
Total	716,174	746,068	890,497	757,147 ^r	821,658 ⁹
Bulgaria, electric furnace: ^e					
Ferrosilicon	8,000	8,000	8,000	8,000	8,000
Other	2,000	2,000	2,000	2,000	2,000
Total	10,000	10,000	10,000	10,000	10,000
Canada, electric furnace: ^e					
Ferrosilicon	56,000	56,000	56,000	56,000	56,000
Ferrovanadium	1,000	1,000	1,000	1,000	1,000
Silicon metal	30,000	30,000	30,000	30,000	30,000
Total	87,000	87,000	87,000	87,000	87,000
Chile, electric furnace:					
Ferromanganese	3,652	2,833	4,011 ^r	4,000 ^{r, e}	4,100
Ferromolybdenum	1,978	2,079	1,454 ^r	1,400 ^{r, e}	1,450
Ferrosilicon	1,159	1,000	1,100 ^r	1,100 ^{r, e}	1,100
Silicomanganese	3,921	2,048	1,800 ^r	1,800 ^{r, e}	1,800
Total	10,710	7,960	8,365 ^r	8,300 ^{r, e}	8,450
China: ^e					
Blast furnace:					
Ferromanganese	550,000	550,000	500,000	500,000	500,000
Other	48,000	100,000	100,000	100,000	100,000

See footnotes at end of table.

TABLE 6--Continued
FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE^{1, 2}

(Metric tons, gross weight)

Country, furnace type, and alloy type ^{3, 4, 5}	1998	1999	2000	2001	2002 ^e
China--Continued: ^e					
Electric furnace:					
Ferrochromium	424,000	400,000	450,000	310,000 ^r	400,000
Ferromanganese	500,000	550,000	520,000	670,000 ^r	700,000
Ferrosilicon	1,290,000	1,120,000	1,400,000	1,320,000 ^r	1,500,000
Silicomanganese	639,000	822,000	900,000	1,170,000 ^r	1,300,000
Other	110,000	258,000	160,000	430,000 ^r	340,000
Total	3,560,000	3,800,000	4,030,000	4,500,000	4,840,000
Colombia, electric furnace, ferronickel	67,100 ^r	67,300 ^r	66,000 ^r	91,500 ^r	104,700 ⁹
Croatia, electric furnace, ferrochromium	11,771	--	15,753	361	--
Czech Republic, electric furnace, other ^e	1,000	1,000	1,000	1,000	1,000
Dominican Republic, electric furnace, ferronickel	69,419	85,000 ^r	84,900 ^r	60,654 ^r	59,654 ⁹
Egypt, electric furnace: ^e					
Ferromanganese	18,000	30,000	30,000	30,000	30,000
Ferrosilicon	44,000	44,000	45,000	45,000	45,000
Total	62,000	74,000	75,000	75,000	75,000
Finland, electric furnace, ferrochromium	230,906	256,290	260,605 ^r	236,710	248,181 ⁹
France: ^e					
Blast furnace, ferromanganese	321,000	302,000 ⁹	300,000	300,000	300,000
Electric furnace:					
Ferromanganese	100,000	138,000	140,000	130,000	130,000
Ferrosilicon	110,000	110,000	110,000	100,000	100,000
Silicomanganese ¹⁰	65,000	55,000	60,000	50,000	50,000
Silicon metal	75,000	75,000	75,000	75,000	75,000
Other	20,000	20,000	20,000	65,000	65,000
Total	691,000	700,000	705,000	720,000	720,000
Georgia, electric furnace: ^e					
Ferromanganese	10,000	6,500	7,000	7,000	7,000
Silicomanganese	35,000	25,000	25,000	25,000	25,000
Total	45,000	31,500	32,000	32,000	32,000
Germany, electric furnace: ^e					
Ferrochromium	20,879 ⁹	16,960 ⁹	21,600 ⁹	19,308 ⁹	20,018 ⁹
Silicon metal	20,000	20,000	26,000	25,000	25,000
Other ¹¹	30,000	30,000	30,000	32,000	30,000
Total	70,900	67,000	77,600	76,300	75,000
Greece, electric furnace, ferronickel	60,020	59,545	81,662	84,200 ^{r, e}	91,600
Hungary, electric furnace: ^{e, 12}					
Ferrosilicon	7,000	7,000	7,000	7,000	7,000
Silicon metal	1,000	1,000	1,000	1,000	1,000
Total	8,000	8,000	8,000	8,000	8,000
Iceland, electric furnace, ferrosilicon	68,000	70,900	70,000 ^e	111,948 ^r	112,000
India, electric furnace: ^e					
Ferrochromium ¹³	345,125 ⁹	312,140 ⁹	376,693 ⁹	267,395 ^{r, 9}	311,927 ⁹
Ferrochromiumsilicon	10,000	10,000	10,000	10,000	10,000
Ferromanganese	165,000	160,000	160,000	165,000	165,000
Ferrosilicon	55,000	55,000	60,000	50,000	52,000
Silicomanganese	193,000	190,000	185,000	150,000	150,000
Other	9,000	9,000	9,000	9,000	9,000
Total	777,000	736,000	801,000	651,000 ^r	698,000
Indonesia, electric furnace:					
Ferromanganese ^e	13,000	12,000	12,000	12,000	12,000
Ferronickel	41,543 ^r	44,068 ^r	47,749 ^r	47,769 ^r	42,306 ⁹
Silicomanganese ^e	7,000	7,000	7,000	7,000	7,000
Total	61,543 ^r	63,068 ^r	66,749 ^r	66,769 ^r	61,300

See footnotes at end of table.

TABLE 6--Continued
FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE^{1, 2}

(Metric tons, gross weight)

Country, furnace type, and alloy type ^{3, 4, 5}	1998	1999	2000	2001	2002 ^c
Iran, electric furnace:					
Ferrochromium	13,745	13,680	11,505	8,430	15,000
Ferrosilicon ^c	40,000	46,000	40,000	40,000	40,000
Total ^c	53,700	59,700	51,500	48,400	55,000
Italy, electric furnace:					
Ferrochromium	11,487	--	--	-- ^c	--
Ferromanganese	49,000	19,000	40,000 ^e	40,000 ^e	40,000
Silicomanganese ^c	70,000	67,000	90,000	90,000	90,000
Silicon metal	8,094	6,257	5,000 ^e	6,000 ^e	6,000
Other ^{c, 14}	10,000	10,000	10,000	10,000	10,000
Total ^c	149,000	102,000	145,000	146,000	146,000
Japan, electric furnace:					
Ferrochromium ¹⁵	142,931	119,777	130,074	111,167	91,937 ⁹
Ferromanganese	334,081	315,152	337,694	368,293	356,717 ⁹
Ferronickel	345,772	332,293	367,181	367,739	370,973 ⁹
Ferrosilicon	951	1,452	--	--	-- ⁹
Silicomanganese	70,886	65,744	67,926	62,238	70,965 ⁹
Other ¹⁶	8,678	12,860	15,020	12,940	12,352 ⁹
Total	903,299	847,278	917,895	922,377	902,944 ⁹
Kazakhstan, electric furnace:					
Ferrochromium	535,000	731,563	799,762	761,900	835,800 ⁹
Ferrochromiumsilicon	33,550	49,282	55,634	79,800	102,200 ⁹
Ferromanganese	--	--	1,075	5,349 ^r	2,278 ⁹
Ferrosilicon	92,000 ^e	140,263	133,269	145,800	127,300 ⁹
Silicomanganese	57,000 ^e	78,495	102,719	141,200	164,000 ⁹
Other ^e	8,000 ⁹	9,000	9,000	9,000	9,000
Total	725,550	1,008,603	1,101,459	1,143,049 ^r	1,240,578 ⁹
Korea, North, electric furnace: ^c					
Ferromanganese ¹¹	6,000	6,000	6,000	6,000	6,000
Ferrosilicon	3,000	3,000	3,000	3,000	3,000
Other ¹²	1,000	1,000	1,000	1,000	1,000
Total	10,000	10,000	10,000	10,000	10,000
Korea, Republic of, electric furnace:					
Ferromanganese	158,418	140,208	146,373	143,525 ^r	146,000
Silicomanganese	106,997	116,091	103,522	101,877 ^r	105,000
Other	2,785	4,639	4,676	4,452 ^r	4,500
Total	268,200	260,938	254,571	249,854 ^r	256,000
Macedonia, electric furnace: ^c					
Ferronickel	15,200 ⁹	5,000 ⁹	--	10,300 ^r	17,000
Ferrosilicon	55,000	50,000	50,000	50,000	50,000
Silicon metal	500	--	--	--	--
Total	70,700	55,000	50,000	60,300 ^r	67,000
Mexico, electric furnace: ¹⁷					
Ferromanganese	86,701 ^r	79,552 ^r	90,501 ^r	60,014	39,000 ⁹
Silicomanganese	104,650 ^r	113,917 ^r	107,923	74,290	73,000 ⁹
Total	191,351 ^r	193,469 ^r	198,424 ^r	134,304	112,000 ⁹
New Caledonia, electric furnace, ferronickel	157,959	157,592	157,000 ^e	162,000 ^e	171,000
Norway, electric furnace: ^c					
Ferrochromium	174,678 ⁹	159,714 ⁹	153,500 ⁹	82,600 ⁹	61,100
Ferromanganese	235,000	235,000	235,000	240,000	240,000
Ferrosilicon	470,000	460,000	460,000	450,000	450,000
Silicomanganese	230,000	230,000	230,000	230,000	230,000

See footnotes at end of table.

TABLE 6--Continued
FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE^{1, 2}

(Metric tons, gross weight)

Country, furnace type, and alloy type ^{3, 4, 5}	1998	1999	2000	2001	2002 ^c
Norway, electric furnace--Continued: ^c					
Silicon metal	110,000	100,000	100,000	100,000	100,000
Other ¹⁰	15,000	15,000	15,000	15,000	15,000
Total	1,230,000	1,200,000	1,190,000	1,120,000	1,100,000
Peru, electric furnace, ferrosilicon ^c	600	600	600	600	600
Poland:					
Blast furnace, ferromanganese ^c	50,152 ⁹	100	-- ^r	500 ^r	500
Electric furnace:					
Ferrochromium	4,200	--	--	-- ^e	--
Ferrosilicon	75,000	62,481	56,000 ^r	48,600 ^r	50,000
Silicomanganese	15,100	10,000	19,000 ^r	20,000 ^r	20,000
Silicon metal ^c	1,400	1,200	1,500	1,500	1,500
Other ^e	11,848 ⁹	2,700	2,700	-- ^r	--
Total	157,700	76,481	79,200 ^r	70,600 ^r	72,000
Romania, electric furnace:					
Ferrochromium	873	--	--	-- ^e	--
Ferromanganese	4,170 ^e	25 ^e	1,044	384 ^r	-- ⁹
Ferrosilicon	5,553	5,000 ^e	5,000 ^e	5,823 ^r	-- ⁹
Silicomanganese	83,617	550 ^e	21,158	71,921 ^r	88,665 ⁹
Silicon metal ^c	150	--	--	--	--
Total	94,363 ^r	5,575 ^r	27,202 ^r	78,128 ^r	88,665 ⁹
Russia: ^c					
Blast furnace:					
Ferromanganese	65,000 ⁹	90,000	70,700	70,000	80,000
Ferrophosphorus	3,500	3,500	3,500	3,500	3,500
Spiegeleisen	7,000	7,000	7,000	7,000	7,000
Electric furnace:					
Ferrochromium	203,000 ⁹	249,000 ⁹	274,000 ⁹	210,600 ⁹	210,000
Ferrochromiumsilicon	4,000	4,500	4,500	4,000	4,000
Ferronickel	30,000	33,000	35,000	30,000	30,000
Ferrosilicon	496,000 ⁹	601,000 ⁹	652,000 ⁹	707,100 ⁹	701,000
Silicon metal	40,000	40,000	40,000	40,000	40,000
Other	40,000	40,000	40,000	35,000	30,000
Total	889,000	1,070,000	1,130,000	1,110,000	1,110,000
Saudi Arabia, electric furnace, other ^c	83,000	83,000	83,000	78,000 ^r	75,000
Serbia and Montenegro, electric furnace, ferronickel	1,243	--	--	--	--
Slovakia, electric furnace: ^c					
Ferrochromium	11,715 ⁹	6,986 ⁹	17,702 ⁹	5,968 ⁹	5,695 ⁹
Ferromanganese	20,000	20,000	20,000	20,000	20,000
Ferrosilicon	49,963 ⁹	50,000	70,000	50,000	50,000
Silicomanganese	46,627 ⁹	35,000	35,000	35,000	35,000
Other	5,000	5,000	5,000	5,000	5,000
Total	133,000	117,000	148,000	116,000	116,000
Slovenia, electric furnace:					
Ferrochromium	10,621	560	--	--	--
Ferrosilicon ^c	8,000	8,000	8,000	8,000	8,000
Other ^{e, 6}	200	200	200	200	200
Total ^e	18,800	8,760	8,200	8,200	8,200
South Africa, electric furnace:					
Ferrochromium	2,025,300	2,155,202	2,574,000	2,141,000 ^r	2,200,000
Ferromanganese	542,000	527,000	596,873	498,000 ^r	500,000
Ferrosilicon	108,400	106,000	109,000	108,000 ^r	110,000
Ferrovanadium ^c	6,000	6,000	18,000	18,000	20,000
Silicomanganese	265,000 ^e	267,000	310,000 ^r	253,000 ^r	260,000

See footnotes at end of table.

TABLE 6--Continued
FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE^{1, 2}

(Metric tons, gross weight)

Country, furnace type, and alloy type ^{3, 4, 5}	1998	1999	2000	2001	2002 ^e
South Africa, electric furnace--Continued:					
Silicon metal	32,600	35,800	40,600	39,000 ^r	40,000
Other ^{e, 18}	15,000	32,000	30,000	30,000	30,000
Total ^e	2,990,000 ^r	3,130,000 ^r	3,680,000 ^r	3,090,000 ^r	3,160,000
Spain, electric furnace: ^e					
Ferrochromium	1,145 ⁹	935 ⁹	905 ⁹	--	--
Ferromanganese	18,000	10,000	10,000	10,000	10,000
Ferrosilicon	39,115 ⁹	40,000	40,000	40,000	40,000
Silicomanganese	108,000	95,000	100,000	100,000	100,000
Silicon metal	18,424 ⁹	28,000	30,000	30,000	30,000
Other	5,000	5,000	5,000	5,000	5,000
Total	190,000	179,000	186,000	185,000	185,000
Sweden, electric furnace:					
Ferrochromium	123,958	113,140	135,841	109,198	118,823 ⁹
Ferrosilicon	20,356	21,440	20,000	22,000 ^e	23,000
Total	144,314	134,580	155,841	131,198 ^r	142,000
Taiwan, electric furnace:					
Ferromanganese	12,532	--	-- ^e	--	-- ⁹
Ferrosilicon	3,775	3,212	2,975	1,181	-- ⁹
Total	16,307	3,212	2,975	1,181	-- ⁹
Turkey, electric furnace:					
Ferrochromium	110,175	99,105	97,640 ^r	50,735	11,200
Ferrosilicon	4,810	420	--	5,895 ^r	7,245 ⁹
Total	114,985	99,525	97,640 ^r	56,630 ^r	18,400
Ukraine:					
Blast furnace: ^e					
Ferromanganese	112,400 ⁹	57,800	85,400	85,000	85,000
Spiegeleisen	2,500	2,500	5,400	5,000	5,000
Electric furnace:					
Ferromanganese	150,000 ^e	199,539	252,679	250,000	250,000
Ferronickel ^e	--	--	10,800	41,000	41,000
Ferrosilicon	222,511	243,600	323,417	325,000	325,000
Silicomanganese	485,560	498,905	684,040	685,000	685,000
Other ^e	20,000	25,000	25,000	25,000	25,000
Total	992,971	1,027,344	1,386,736	1,416,000 ^r	1,420,000
United States, electric furnace:					
Ferrochromium ¹⁹	W	W	W	W	W
Ferromanganese ²⁰	W	W	W	W	W
Ferronickel	8,590	--	-- ^e	--	--
Ferrosilicon	334,000	325,000	250,000 ^e	191,000	182,000 ⁹
Silicon metal	188,000	186,000	175,000 ^e	131,000	108,000 ⁹
Other ²¹	W	W	W	W	W
Total	531,000	511,000	425,000 ^e	322,000	290,000
Uruguay, electric furnace, ferrosilicon ^e	200	200	200	200	200
Venezuela, electric furnace:					
Ferromanganese	7,671	10,694	15,655	12,715 ^r	12,000
Ferronickel	--	--	133	32,300 ^r	51,700
Ferrosilicon	36,277	38,886	56,926	46,236 ^r	58,000
Silicomanganese	48,504	47,635	69,735	56,640 ^r	55,000
Total	92,452	97,215	142,449	147,891 ^r	177,000
Zimbabwe, electric furnace:					
Ferrochromium	246,782	244,379	246,324	243,584 ^r	258,164 ⁹
Ferrochromiumsilicon	21,000	16,267	19,631	16,848	-- ⁹
Total	267,782	260,646	265,955	260,432 ^r	258,164 ⁹

See footnotes at end of table.

TABLE 6--Continued
FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE^{1, 2}

(Metric tons, gross weight)

Country, furnace type, and alloy type ^{3, 4, 5}	1998	1999	2000	2001	2002 ^c
Grand total:	17,500,000	17,900,000	19,600,000 ^r	19,000,000 ^r	19,600,000
Of which:					
Blast furnace:					
Ferromanganese ²²	1,100,000	1,000,000	956,000	956,000 ^r	966,000
Spiegeleisen ²²	9,500	9,500	12,400	12,000	12,000
Other ²³	51,500	104,000	104,000	104,000	104,000
Total	1,160,000	1,110,000	1,070,000	1,070,000	1,080,000
Electric furnace:					
Ferrochromium ²⁴	4,750,000	5,000,000	5,720,000	4,680,000	4,980,000
Ferrochromiumsilicon	73,600 ^r	85,000 ^r	94,800 ^r	116,000 ^r	121,000
Ferromanganese ^{25, 26}	2,690,000 ^r	2,680,000 ^r	2,860,000	2,880,000 ^r	2,880,000
Ferronickel	828,000 ^r	808,000 ^r	874,000 ^r	949,000 ^r	1,000,000
Ferrosilicon	3,900,000	3,900,000	4,240,000 ^r	4,130,000 ^r	4,290,000
Silicomanganese ^{26, 27}	2,890,000	2,960,000 ^r	3,430,000 ^r	3,650,000 ^r	3,830,000
Silicon metal	686,000	681,000	729,000	629,000 ^r	610,000
Other ²⁸	510,000 ^r	669,000 ^r	586,000 ^r	880,000 ^r	782,000
Total	16,300,000	16,800,000	18,500,000 ^r	17,900,000 ^r	18,500,000

^cEstimated. ^rRevised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

¹World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

²Table includes data available through August 21, 2003.

³In addition to the countries listed, Iran is believed to have produced ferromanganese and silicomanganese, but production is not reported; general information is inadequate for the formulation of reliable estimates of output levels.

⁴To the extent possible, ferroalloy production of each country has been separated according to the furnace from which production is obtained; production derived from metallothermic operation is included with electric furnace production.

⁵To the extent possible, ferroalloy production of each country has been separated to show the following individual major types of ferroalloys: ferrochromium, ferrochromiumsilicon, ferromanganese, ferronickel, ferrosilicon, silicomanganese, silicon metal, and spiegeleisen. Ferroalloys other than those listed that have been identified specifically in sources, as well as those ferroalloys not identified specifically, but which definitely exclude those listed previously in this footnote, have been reported as "Other." Where one or more of the individual ferroalloys listed separately in this footnote have been inseparable from other ferroalloys owing to a nation's reporting system, deviations are indicated by individual footnotes.

⁶Includes calcium-silicon.

⁷Includes, if any, silicomanganese.

⁸Includes high- and low-carbon ferrochromium.

⁹Reported figure.

¹⁰Includes, if any, silicospiegeleisen.

¹¹Includes, if any, ferrochromiumsilicon and ferronickel.

¹²Hungary is believed to produce some blast furnace ferromanganese.

¹³Includes charge chrome and ferrochrome.

¹⁴Excludes calcium-silicon.

¹⁵Includes high- and low-carbon ferrochromium and ferrochromiumsilicon.

¹⁶Includes calcium-silicon, ferrocolumbium, ferromolybdenum, ferrotungsten, ferrovanadium, and other ferroalloys.

¹⁷Salable products from Autlán.

¹⁸Includes, if any, ferronickel.

¹⁹U.S. output of ferrochromium includes chromium metal, high- and low-carbon ferrochromium, ferrochromiumsilicon, and other chromium materials.

²⁰U.S. output of ferromanganese includes manganese metal and silicomanganese.

²¹May include ferroboration, ferrocolumbium, ferromolybdenum, ferrophosphorus, ferrotitanium, ferrotungsten, ferrovanadium, nickel columbium, and silvery pig iron.

²²Spiegeleisen, if any, for Germany is included with blast furnace ferromanganese.

²³Includes ferrophosphorus and data contained in "Blast furnace, other."

²⁴Ferrochromium includes ferrochromiumsilicon, if any, for Japan, South Africa, and the United States.

²⁵Ferromanganese includes silicomanganese, if any, for North Korea.

²⁶U.S. production is included in "Other."

²⁷Includes silicospiegeleisen, if any, for France.

²⁸Includes calcium-silicon, ferromolybdenum, ferrovanadium, silicomanganese for the United States, and data contained in "Electric furnace, other" for each country indicated.